

AMSR-E snow product developments and improvements

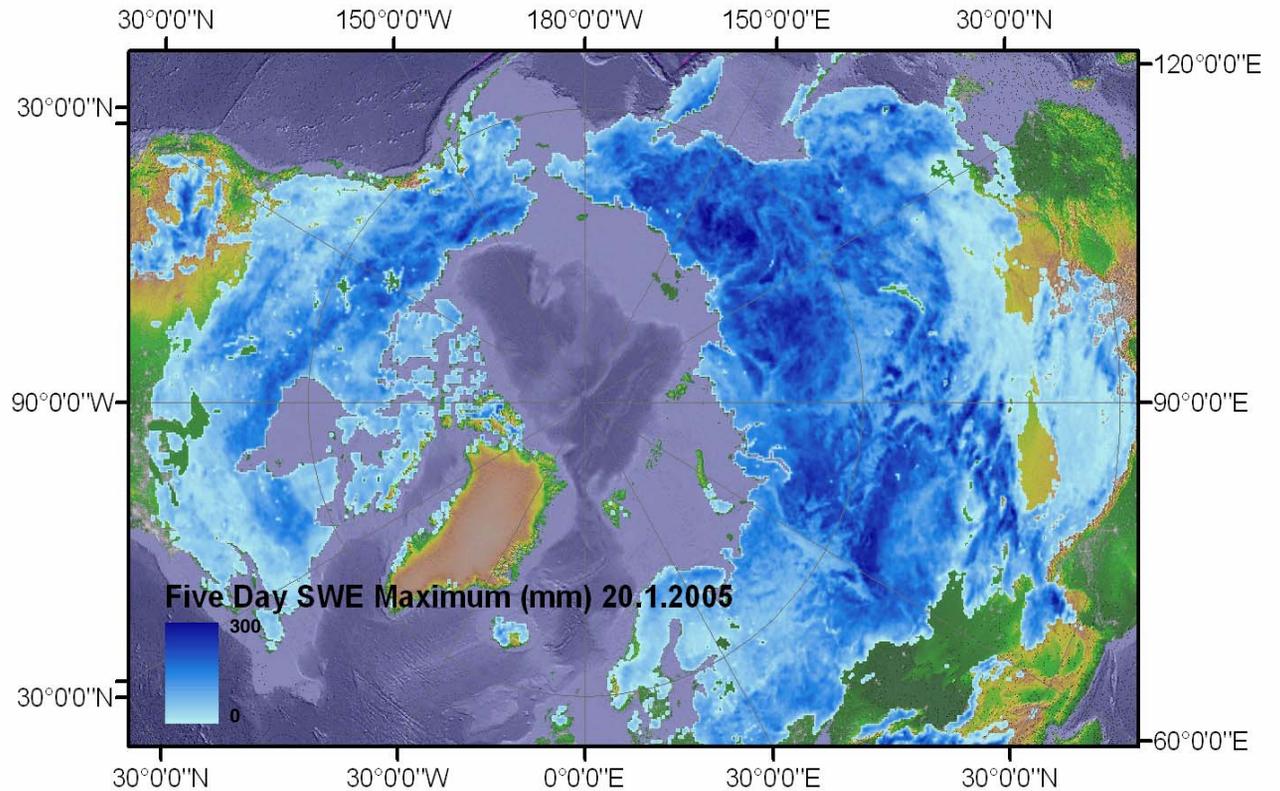
Richard Kelly^{1,2} & James Foster²

**¹Goddard Earth Science and Technology
University of Maryland Baltimore County**

&

**²Laboratory for Hydrospheric and Biospheric
Processes, NASA/GSFC**





Outline

- Algorithm Updates
- Validation
- Future developments



Baseline algorithm for AMSR-E daily product

Brightness temperature at 18
and 36 GHz H-Polarization

$SD = 4.8$

$$\left[\frac{Tb18H - Tb36H}{(1 - 0.6 ff)} \right] mm$$

Time & space static
coefficient (based on grain
size 0.3 mm radius and
density 0.3 g cm⁻³)

Forest fraction (derived from
Robinson & Kukla, 1986)

Selected sources

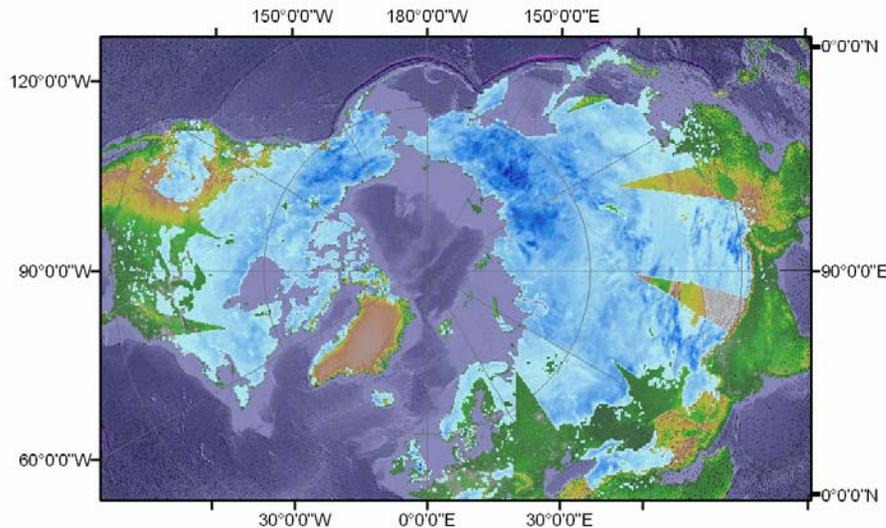
Chang, A.T.C., J.L. Foster and D.K. Hall, Nimbus-7 derived global snow cover parameters, *Ann. Glaciol.*, vol. 9, pp. 39-44, 1987.

Chang, A.T.C., J.L. Foster, D.K. Hall, A. Rango and B.K. Hartline, Snow water equivalent estimation by microwave radiometry, *Cold Reg. Sci. Technol.*, vol. 5, pp. 259-267, 1982.

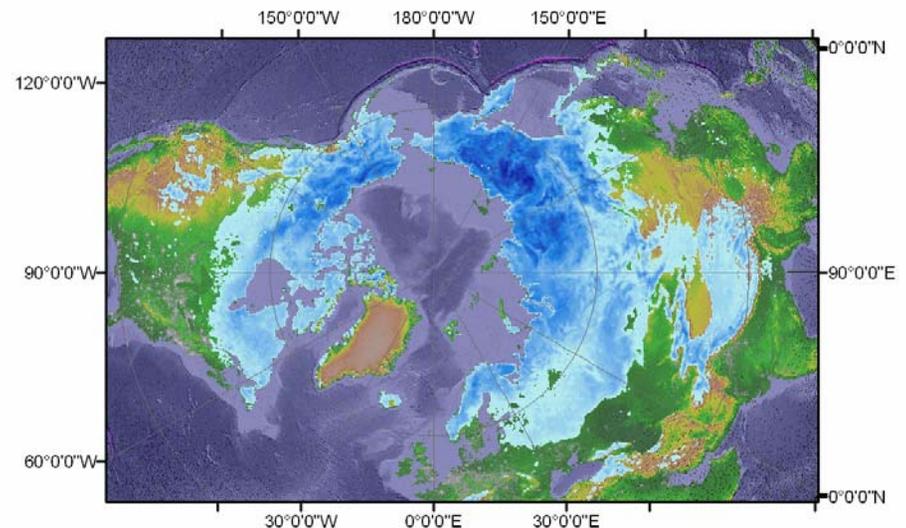
Foster, J.L., A.T.C. Chang and D.K. Hall, Comparison of snow mass estimates from a prototype passive microwave snow algorithm, a revised algorithm and snow depth climatology, *Remote Sens. Environ.*, vol. 62, pp. 132-142, 1997.

Chang, A.T.C., J.L. Foster and D.K. Hall, Effects of forest on the snow parameters derived from microwave measurements during the BOREAS winter field experiment. *Hydrol. Process.*, vol. 10, 1565-1574, 1996.

- Daily, Pentad & Monthly Products
- EASE-Grid northern and southern hemisphere products [721x721 grid cells per hemisphere = 25x25 km cells]
- Pentad and Monthly products are maximum SWE



Daily: 19 January 2005



Monthly: April 2005

Algorithm updates

Snow detection

– Thresholds:

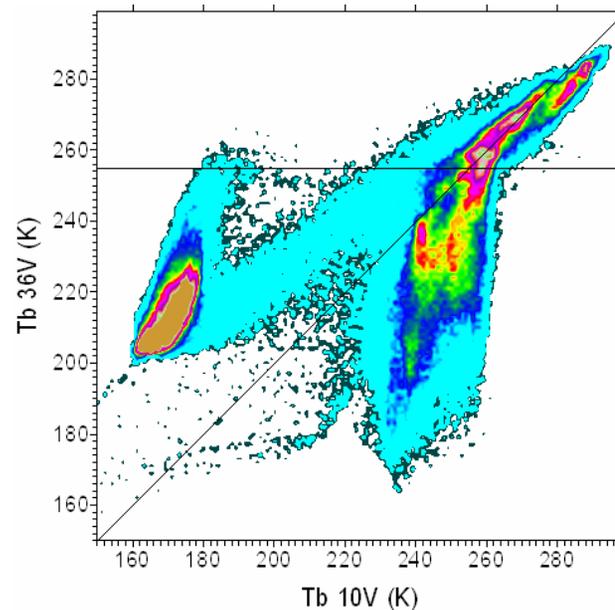
- $T_{b18V \text{ or } H} < 245K \ \&\& \ T_{b36V \text{ or } H} < 255K$

– Detect not shallow scattering:

- $10V-36V > 0 \ \text{or} \ 10H-36H > 0$

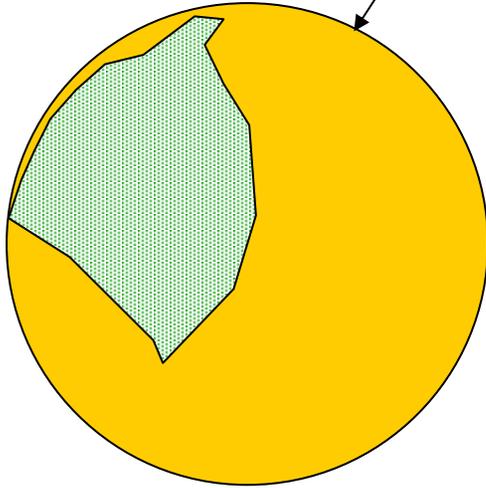
– Detect shallow snow:

- $10V-36V \leq 0 \ \&\& \ 10H-36H \leq 0 \ \&\& \ 22V-89V > 0 \ \&\& \ 22H-89H > 0 \ \&\& \ T_{\text{est}} < 273K$
- $T_{\text{est}} = 58.08 - 0.39 \cdot 18V + 1.21 \cdot 23V - 0.37 \cdot 36H + 0.36 \cdot 89V \text{ (K)}$
- $SD = 5\text{cm}$

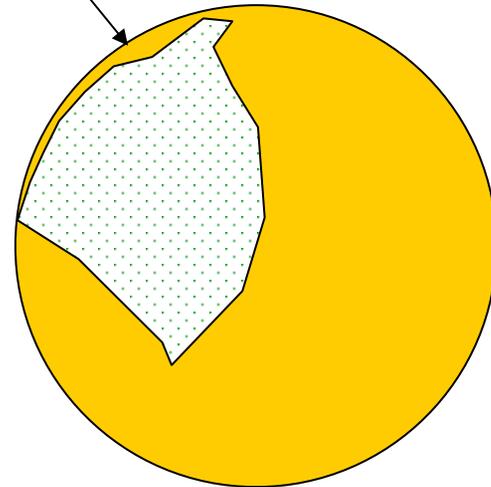


Forest cover definition

AMSR-E IFOV (36GHz)
Forest Cover % (of IFOV) = 35%

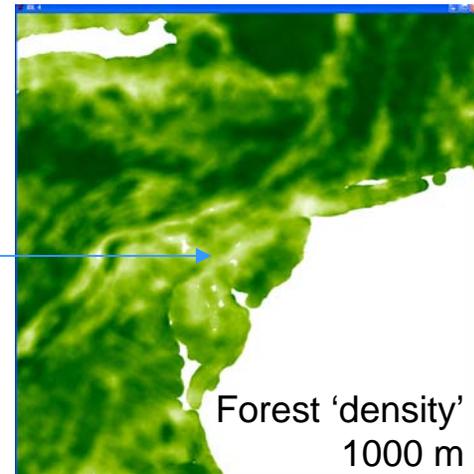
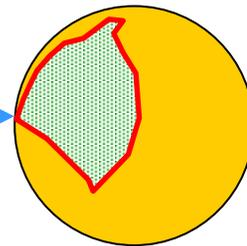
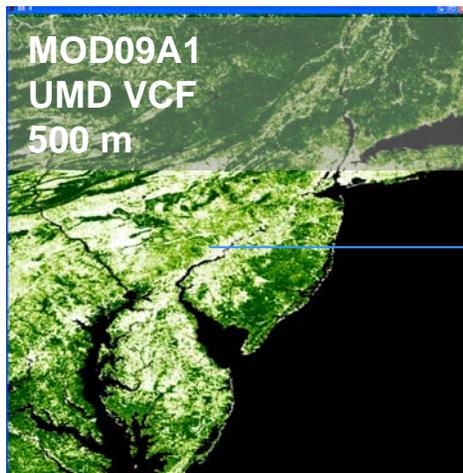
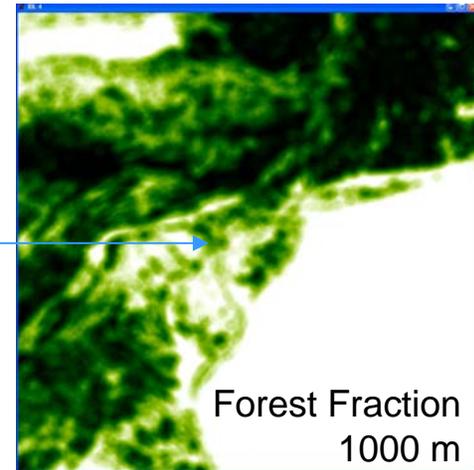
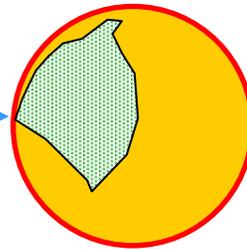
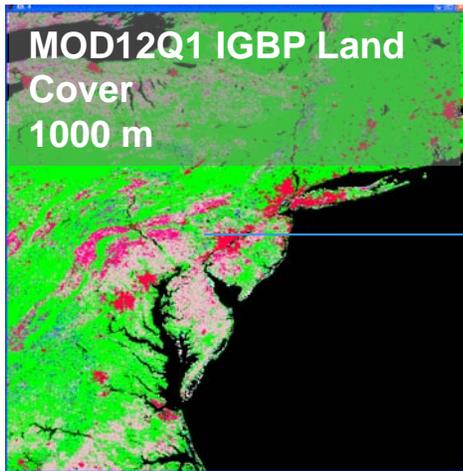


Forest 'Density' = 60%
(high degree of canopy closure)



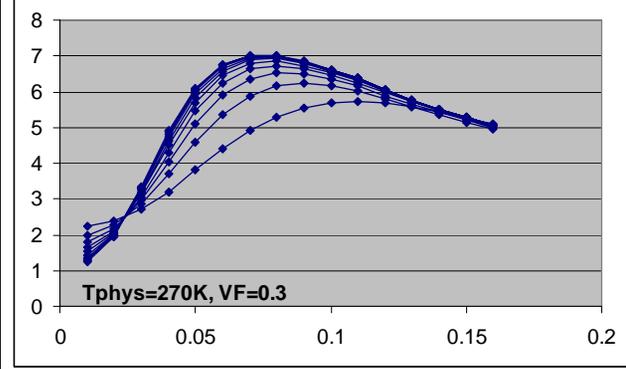
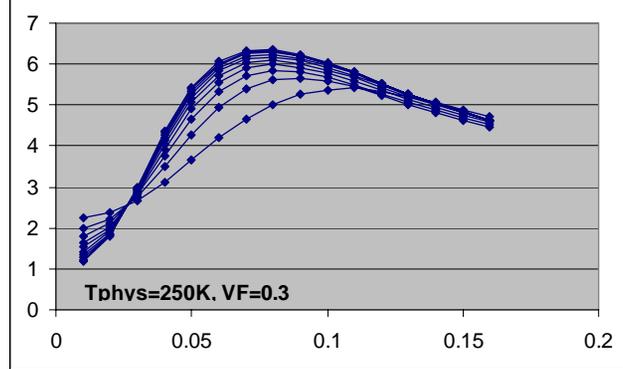
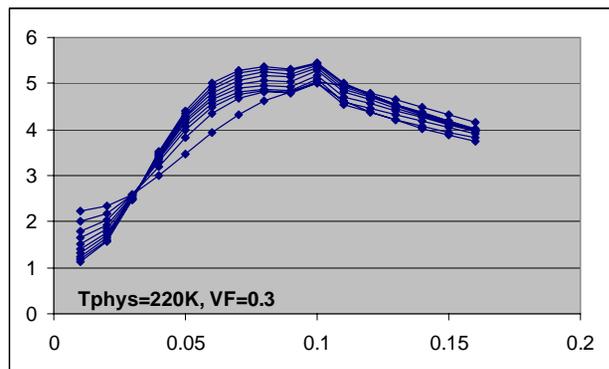
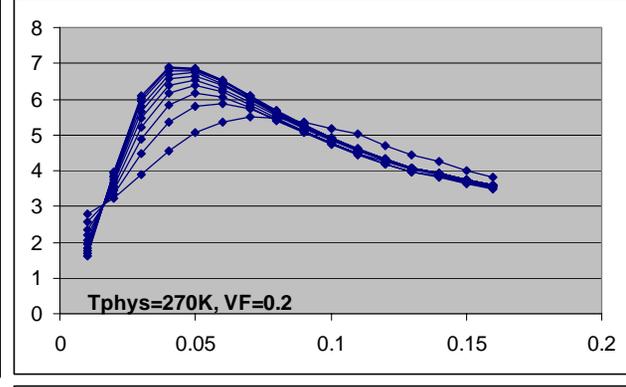
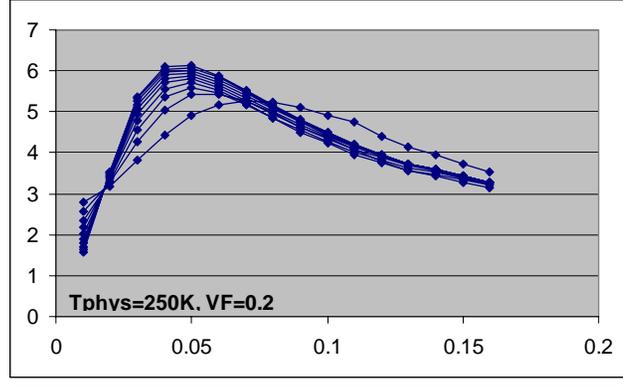
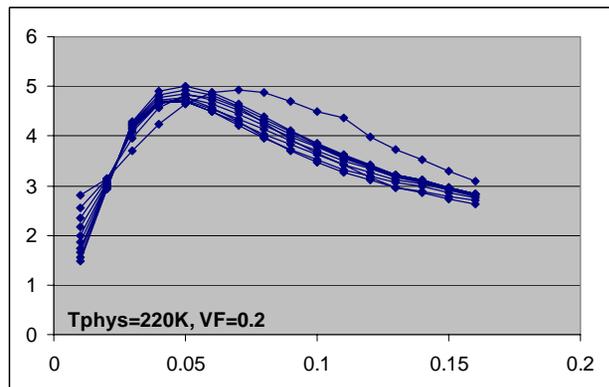
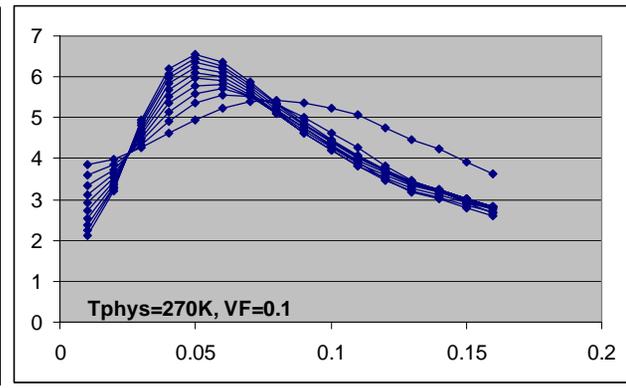
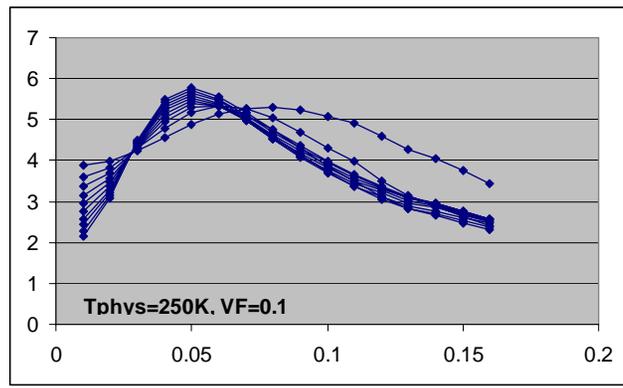
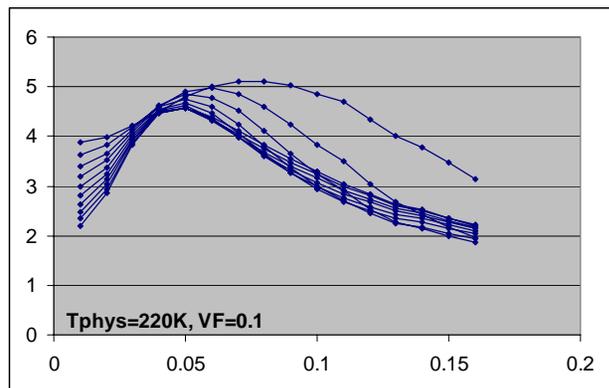
Forest 'Density' = 20%
(low degree of canopy closure)

Forest cover definition (cont.)



Dynamic algorithm parameterization

DMRT: Grain Radius (x-axis) vs. 36 GHz Pol. (y-axis) for different SD (10-100 cm)



Dynamic algorithm parameterization (cont.)

Retrieved snow depth (SD) excluding shallow snow:

$$SD = ff (SD_f) + (1-ff) * (SD_o) \quad [cm]$$

- SD_f is the snow depth from the forest component of the instantaneous field of view (IFOV)
- SD_o is the snow depth from non-forested component of the IFOV.
- ff is the forest fraction ($ff = 1$ for 100% forest fraction; $ff = 0$ for 0% forest fraction).

$$SD_f = 1/\log_{10}(pol36) * (Tb18V-Tb36V)/(1-fd*0.6) \quad [cm]$$

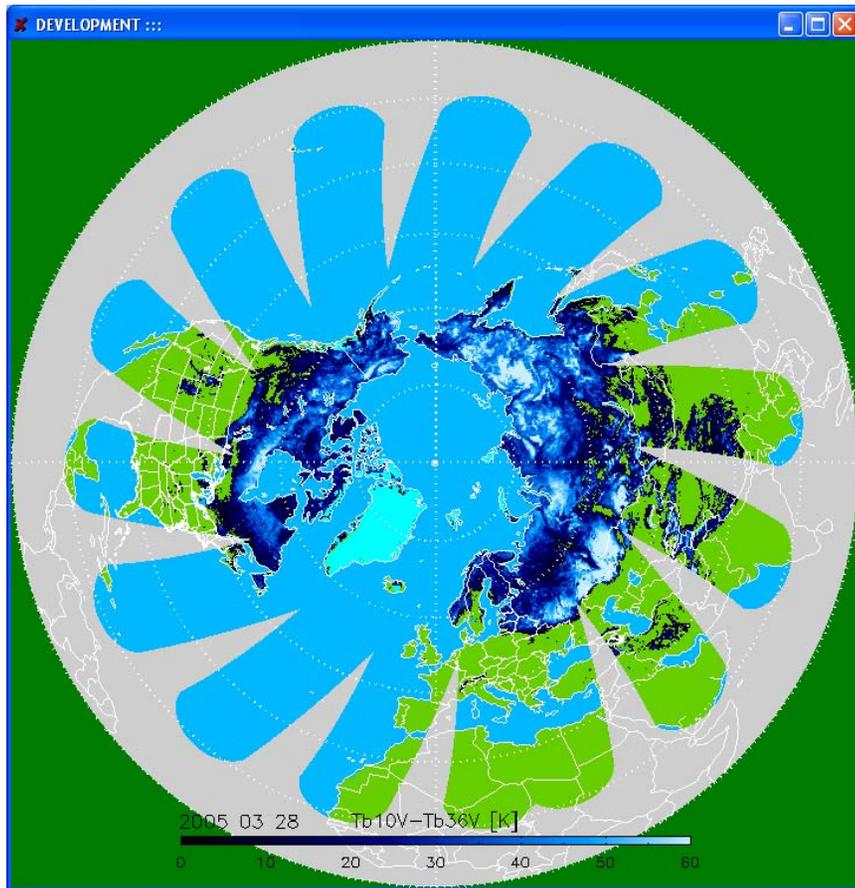
- fd = high spatial resolution forest density (500m)
- $pol36 = Tb36V - Tb36H$
- *NOTE - Use of 18V-36V to maximize spatial resolution in forested areas.*
- *NOTE - fd is scaled through optimization of validation data.*

$$SD_o = [1/\log_{10}(pol36)*(Tb10V-Tb36V)] + [1/\log_{10}(pol18)*(Tb10v-Tb18V)] \quad [cm]$$

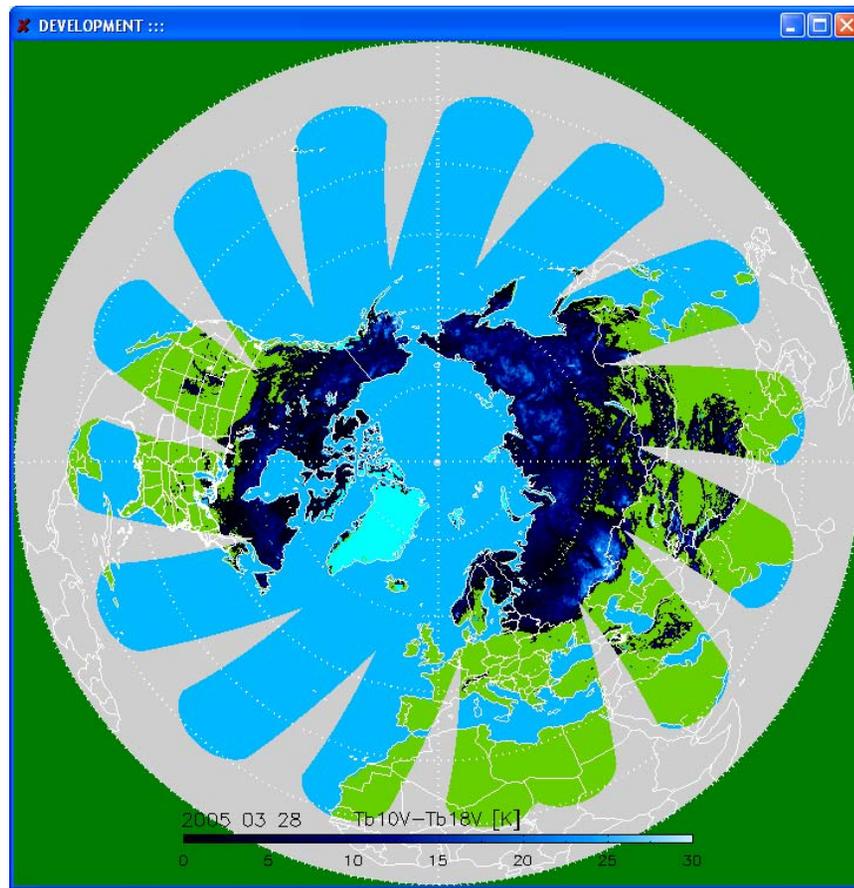
- $pol18 = Tb18V - Tb186H$
- *NOTE - Use of 10V-36V (increased dynamic range) and 10V-18V (deep snow)*



10V-36V



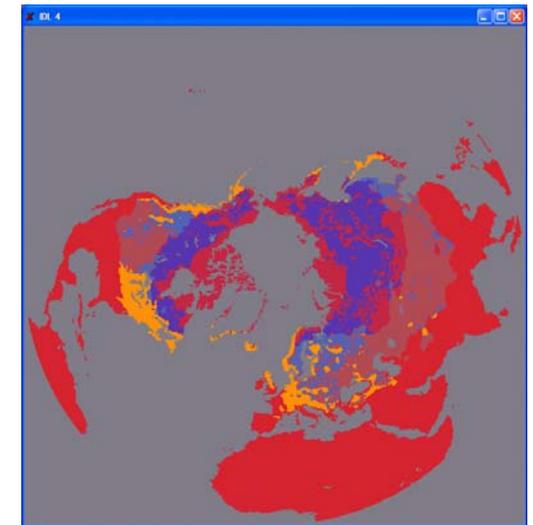
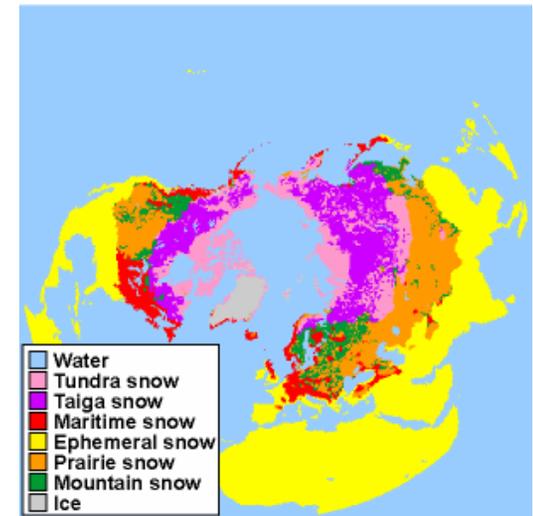
10V-18V



Conversion of snow depth to SWE

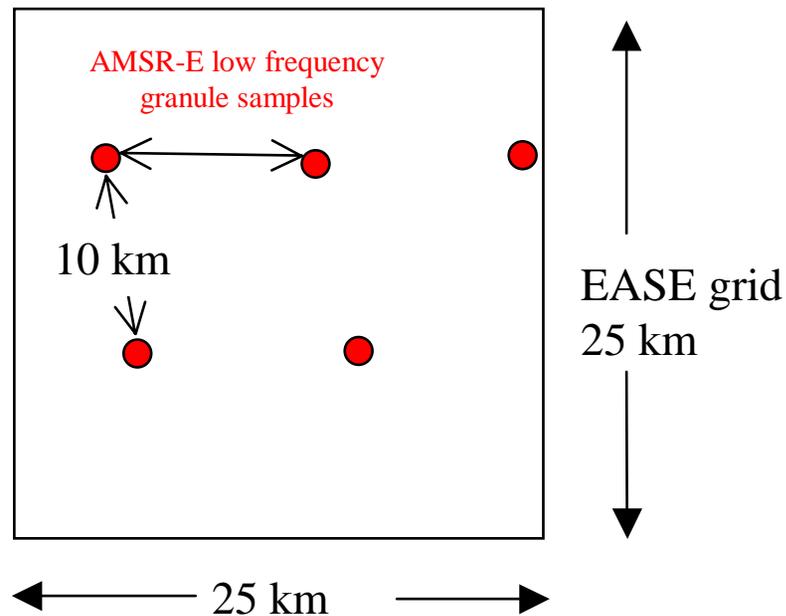
- AMSR-E algorithm is calibrated for snow depth. To convert to SWE we use the Sturm *et al.* (1995) Seasonal Snow Classes and map long-term density measures from Canada and FSU data sets. The following gives a summary of the different class densities in g cm^{-3} .
- Sturm class Tundra: density = 0.26
- Sturm class Taiga: density = 0.20
- Sturm class Maritime: density = 0.24
- Sturm class Ephemeral: density = 0.24
- Sturm class Prairie: density = 0.23
- Sturm class Mountain density = 0.23

Global Mean = 0.24 g cm^{-3} (used when missing data).



Retrieval spatial framework

Retrievals now done at the IFOV scale (each 10 km) and then averaged up to the 25 km x 25 km EASE-Grid scale.



Validation

(with WMO GTS Global Surface Observations of the Day)

	2002	2002	2003	2003
1.6(18v-36v)/(1-0.2ff)	RMSE	Bias	RMSE	Bias
All Data	24.01	6.49	24.37	6.07
FF = 0%	24.63	11.32	26.19	5.68
0% < FF < 50%	24.60	4.38	23.96	7.05
FF > 50%	16.82	0.15	18.03	-1.10
	2002	2002	2003	2003
New Algo (Pol >=3)	RMSE	Bias	RMSE	Bias
All Data	21.83	-1.04	22.35	-2.43
FF = 0%	21.41	0.78	24.01	-4.57
0% < FF < 50%	22.76	-2.49	21.84	-1.25
FF > 50%	16.45	1.62	17.31	-2.41

Ground data carefully screened.



Validation (cont.) - Collaboration when possible

REGIONAL SPECIFIC TESTING (CONTACTS)

- **Russia:** **Research Center for Space Information Systems and Observation Technologies, Moscow.**
- **Chile:** **Centro de Estudios Avanzados en Zonas AridasCasilla, Chile**
- **Turkey:** **Middle East Technical University, Ankara**
- **India:** **Defence R&D Organisation, Chandigarth, Punjab**

REGIONAL TESTING (ORGS/OPERATIONAL DATA SETS)

- **Alaska:** **NPS DATA**
- **Siberia:** **GAME/CEOP JAXA**
- **Ob Basin:** **WMO GTS GSOD**
- **Canada:** **MSC**
- **Colorado:** **CLPX**

PRODUCT COMPARISONS

- **MODIS**
- **AFWA**
- **NOHRSC**



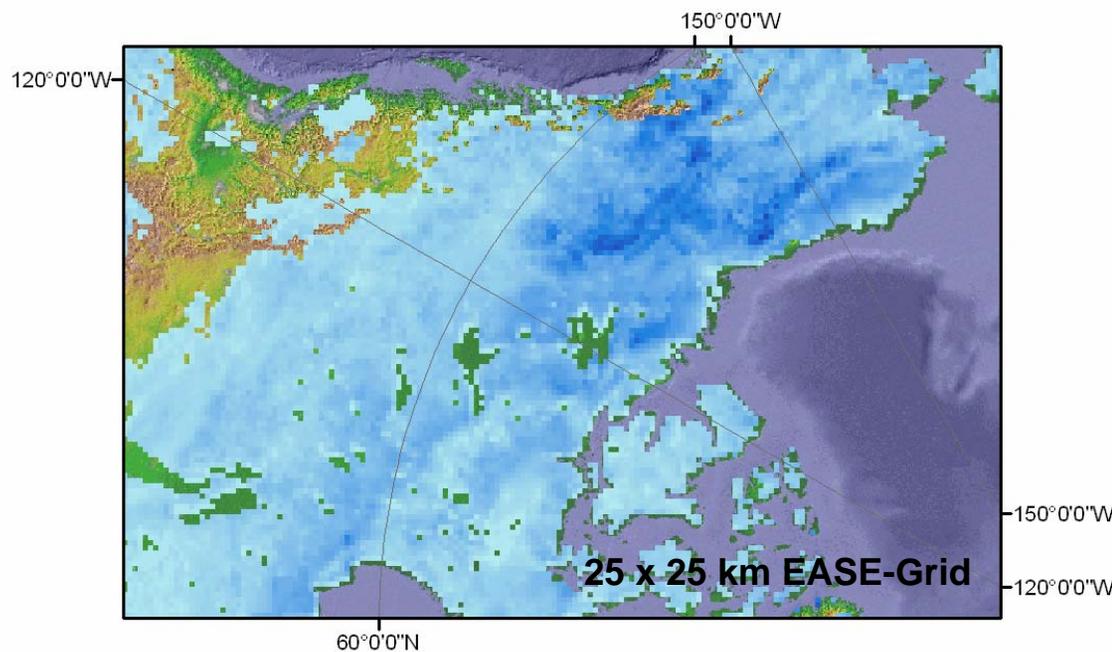
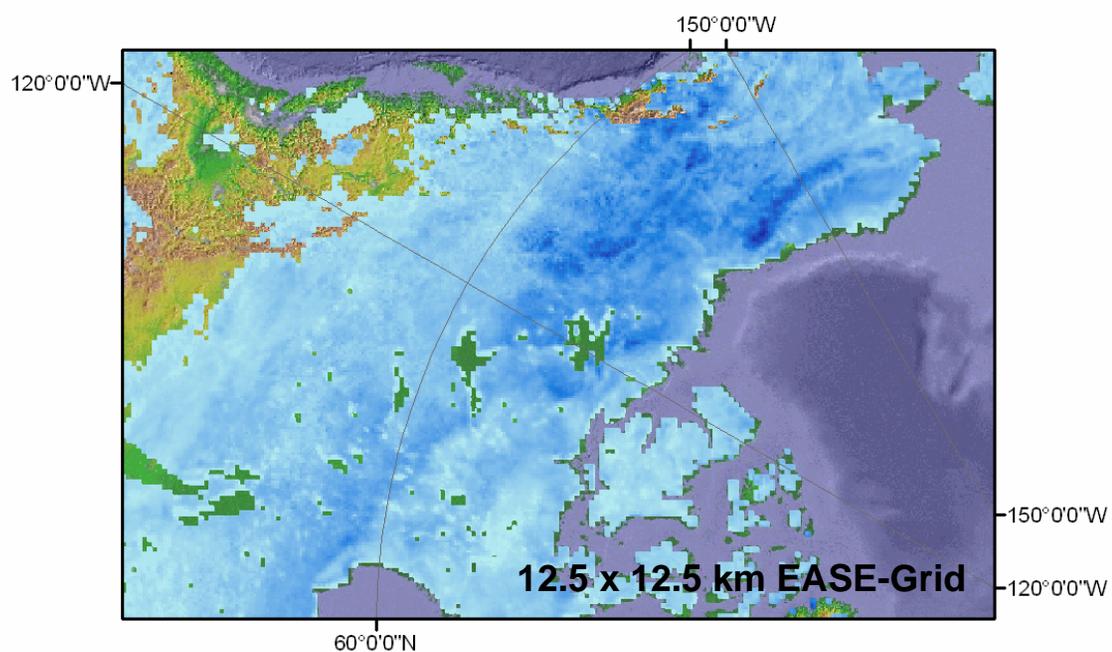
Future Developments

RETRIEVAL FRAMEWORK

- *Gridding to 12.5 x 12.5 km resolution (rather than 25 x 25 km resolution)*
[Collaboration w/ Savoie, Armstrong & Brodzik at NSIDC]

RETRIEVALS

- *On-the-fly confidence ascribing from validation efforts.*
- *Implementation of physically-based or semi-physically-based inversion modelling framework still some way out (DMRT, Direct solution to Maxwell etc.).*
- *Signature studies ongoing.*



This is a collaborative effort with thanks due to:

GSFC (AC, Jim Foster, Dorothy Hall), NSIDC (Richard Armstrong, Mary Jo Brodzik), MSC Canada (Barry Goodison, Anne Walker, Chris Derksen), University of Washington, Seattle (Leung Tsang), AMSR-E Science Team (Leaders, Roy Spencer and Elena Lobl), NASA HQ (Jarred Entin) and many others.

